

Fig. 1

[illegible]



$\sim 90^\circ$ ,  $\sim 80^\circ$ ,  $\sim 70^\circ$ ,  $\sim 60^\circ$ ,  $\sim 50^\circ$ ,  $\sim 40^\circ$ ,  $\sim 30^\circ$ ,  $\sim 20^\circ$ ,  $\sim 10^\circ$

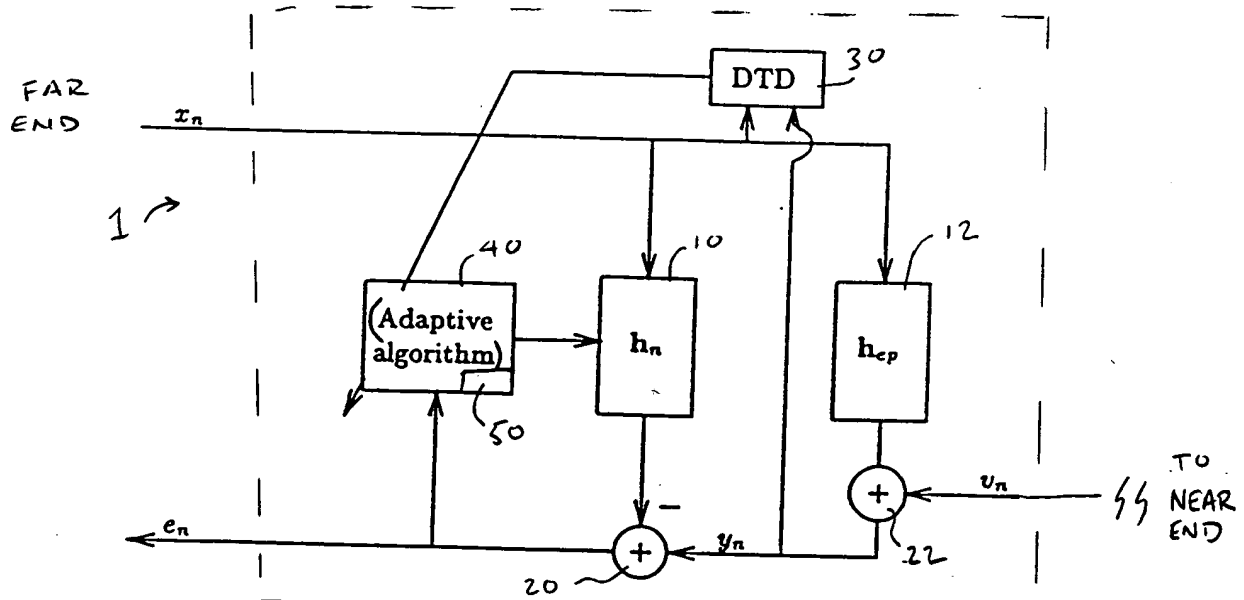


FIG. 3

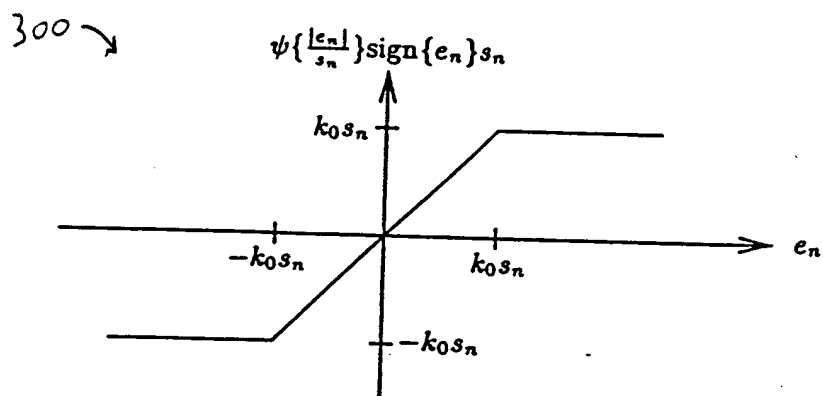


FIG. 4

Equation	Instructions/sample	Memory loc.
$\min\{ e_n , s_n\} \text{sign}\{e_n\}$	3	2
$s_{n+1} = \lambda s_n + \frac{k_0(1-\lambda)}{\beta} \min\{ e_n , s_n\}$	4	2
Total	7	4

FIG. 5

Figure 3: (a) Impulse response and (b) magnitude of the frequency response of the hybrid.

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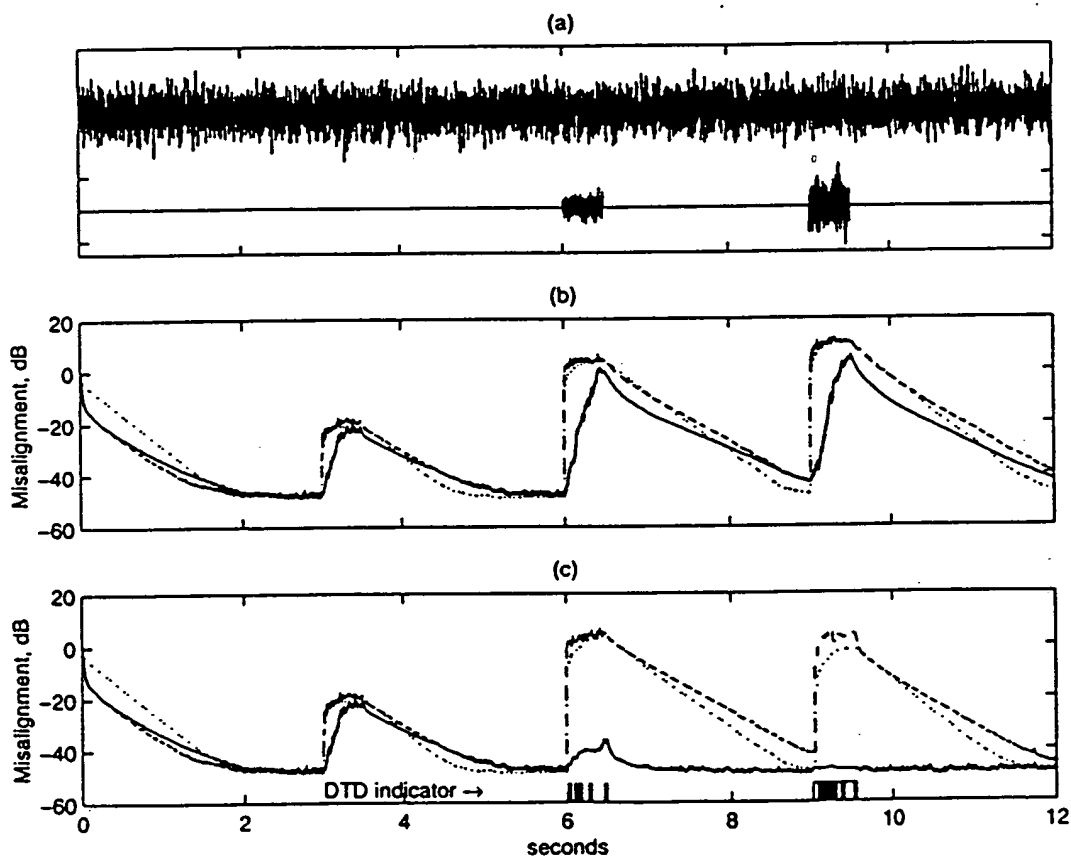


Figure 4: Performance during double-talk for parameter setting  $\lambda = 0.997$ ,  $k_0 = 1.1$  (a) Far- and near-end signals. Far- to near-end ratio: 30 dB (3 – 3.5 s), 6 dB (6 – 6.5 s), 0 dB (9 – 9.5 s). (b) Misalignment without double-talk detector. (c) Misalignment with double-talk detector. Solid line: R-PNLMS++, Dashed line: PNLMS++, Dotted line: NLMS. The small vertical bars indicate when double-talk is declared.

FIG. 7

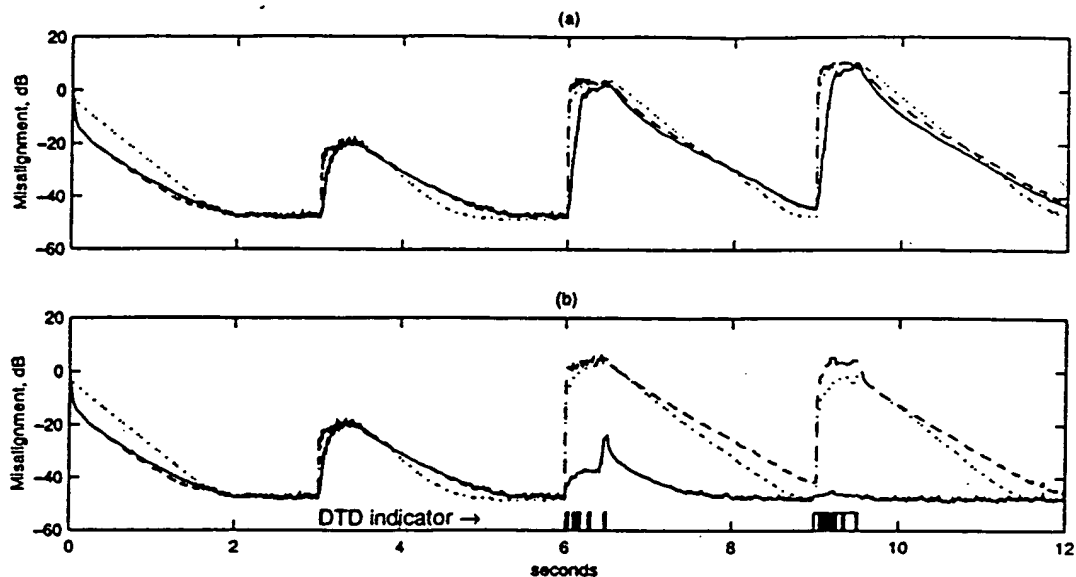


Figure 5: Performance during double-talk for parameter setting  $\lambda = 0.995$ ,  $k_0 = 1.5$ . Far- to near-end ratio: 30 dB (3 – 3.5 s), 6 dB (6 – 6.5 s), 0 dB (9 – 9.5 s). (a) Misalignment without double-talk detector. (b) Misalignment with double-talk detector. Solid line: R-PNLMS++, Dashed line: PNLMS++, Dotted line: NLMS. The small vertical bars indicate when double-talk is declared.

FIG. 8



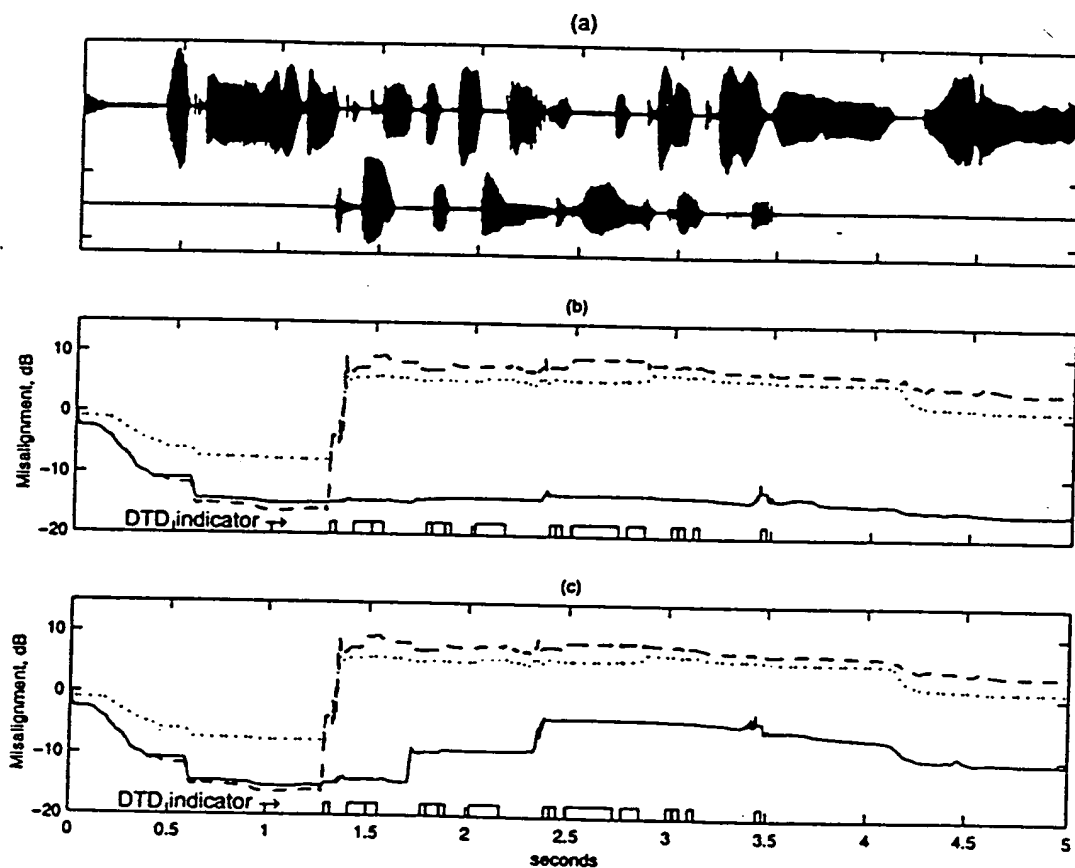


Figure 6: Double-talk, speech signal. (a) Far- and near-end signals. Average far- to near-end ratio: 6 dB (1.125-3.125 s). (b) Misalignment,  $\lambda = 0.997$ ,  $k_0 = 1.1$ . (c) Misalignment,  $\lambda = 0.995$ ,  $k_0 = 1.5$ . Solid line: R-PNLMS++, Dashed line: PNLMS++, Dotted line: NLMS.

FIG. 9

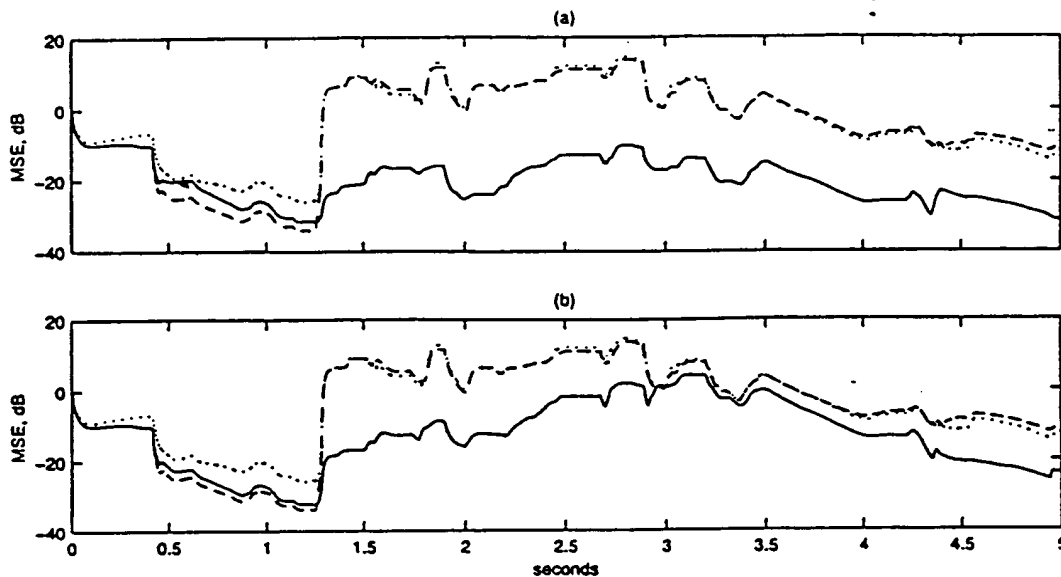


Figure 7: Double-talk, speech signal as in Fig. 6a. (a) shows MSE when  $\lambda = 0.997$ ,  $k_0 = 1.1$ . (b) shows MSE when  $\lambda = 0.995$ ,  $k_0 = 1.5$ . Solid line: R-PNLMS++, Dashed line: PNLMS++, Dotted line: NLMS.

FIG. 10

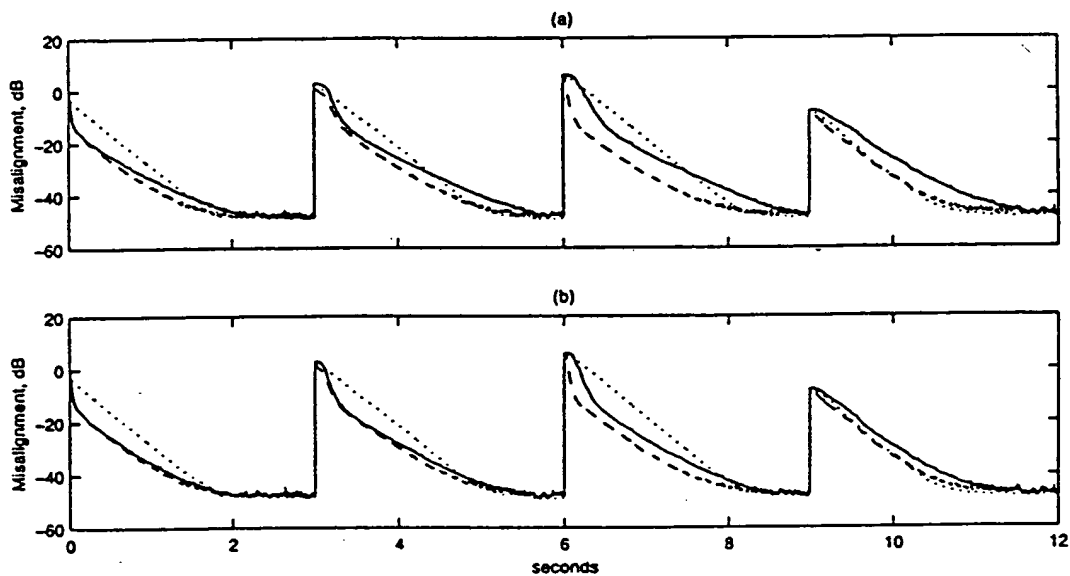


Figure 8: Reconvergence after abrupt hybrid changes. Case A at 3 s, Case B at 6 s and Case C at 9 s. (See Section 4.2.2 for a definition the three conditions). (a)  $\lambda = 0.997$ ,  $k_0 = 1.1$  (b)  $\lambda = 0.995$ ,  $k_0 = 1.5$ . Solid line: R-PNLMS++, Dashed line: PNLMS++, Dotted line: NLMS.

FIG. 11

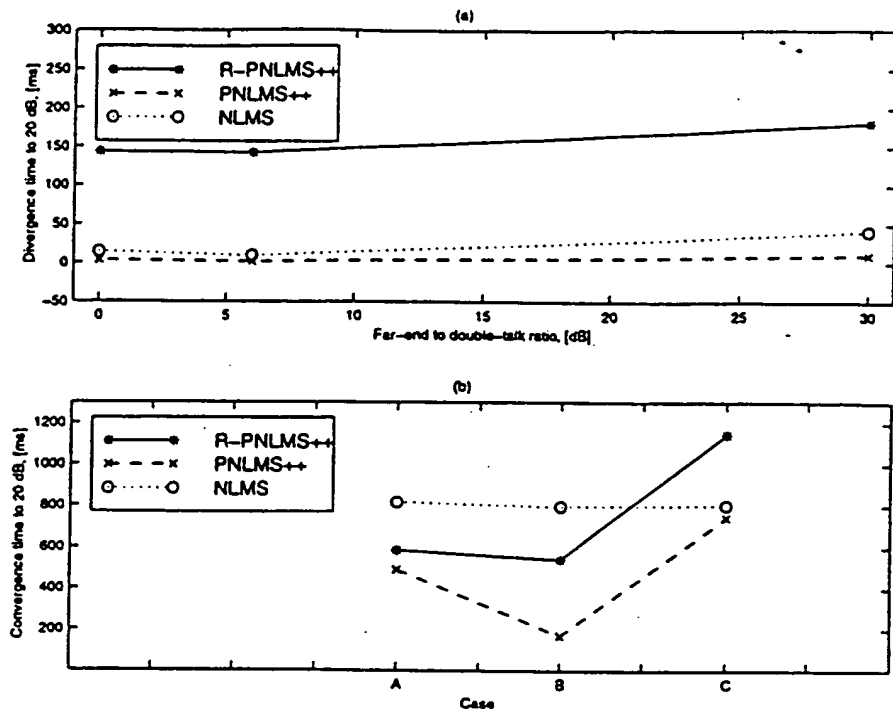


Figure 9: Divergence (a) and convergence (b) time to 20 dB change of misalignment.  $\lambda = 0.997$ ,  $k_0 = 1.1$ . Solid line: R-PNLMS++, Dashed line: PNLMS++, Dotted line: NLMS.

FIG. 12

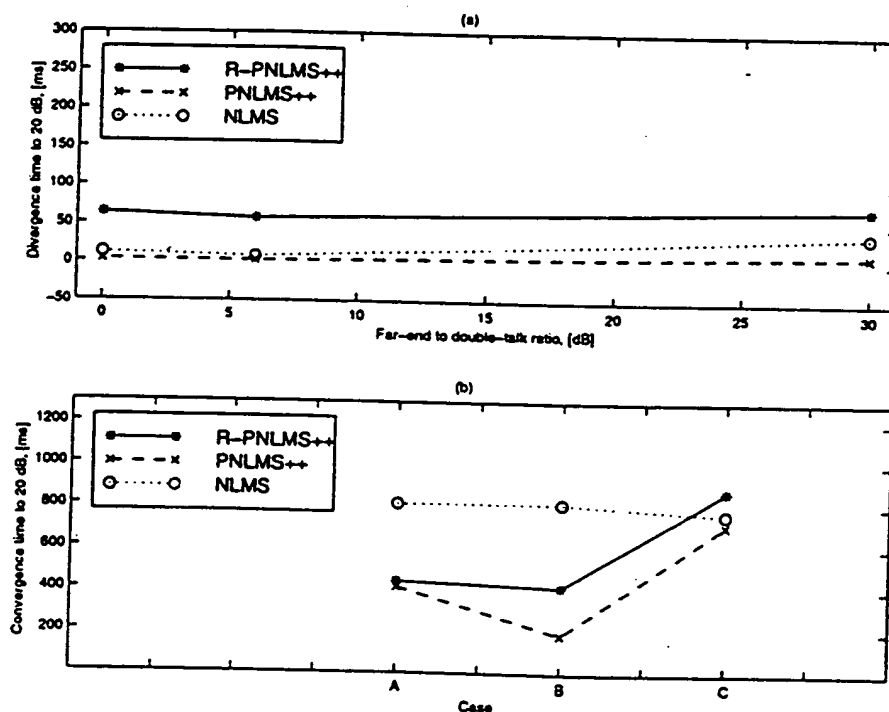


Figure 10: Divergence (a) and convergence (b) time to 20 dB change of misalignment.  $\lambda = 0.995$ ,  $k_0 = 1.5$ . Solid line: R-PNLMS++, Dashed line: PNLMS++, Dotted line: NLMS.

FIG. 13

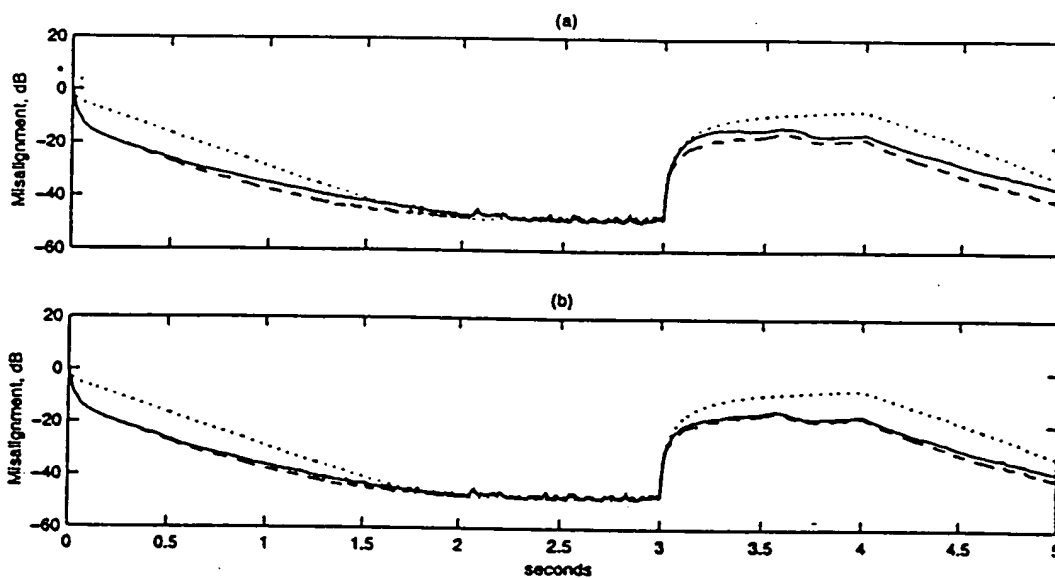


Figure 11: Misalignment when tracking a nonstationary hybrid, 3 - 4 s. (a)  $\lambda = 0.997$ ,  $k_0 = 1.1$ . (b)  $\lambda = 0.995$ ,  $k_0 = 1.5$ . Solid line: R-PNLMS++, Dashed line: PNLMS++, Dotted line: NLMS.

FIG. 14

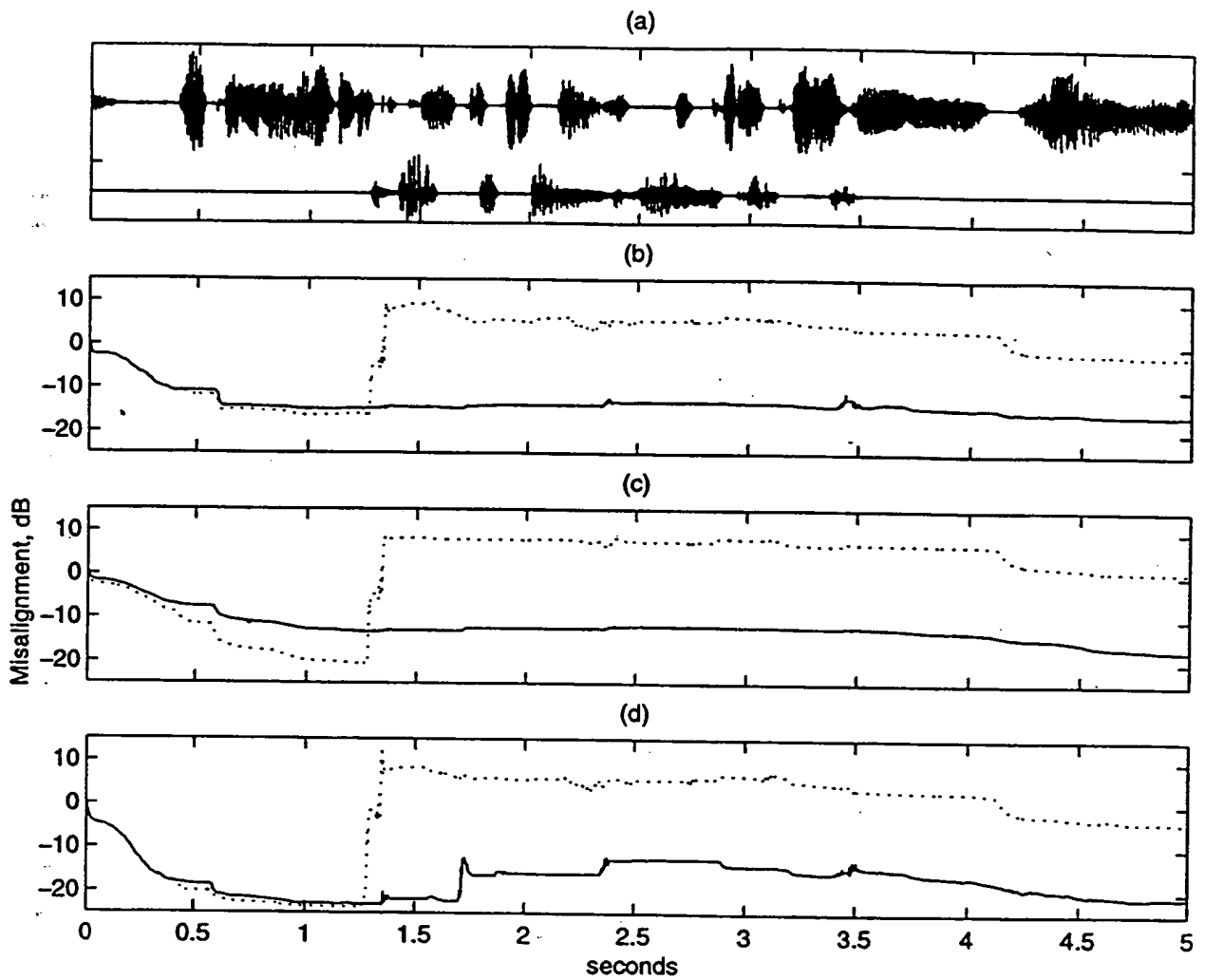


Figure 4: Misalignment during double-talk starting at 1.25 seconds. Far- to near-end ratio: 6 dB. (a) Far (upper) and near-end (lower) signals. (b) Solid line: R-PNLMS++, Dotted line: PNLMS++. (c) Solid line: R-APA, Dotted line: APA. (d) Solid line: R-PAPA, Dotted line: PAPA.

FIG. 15

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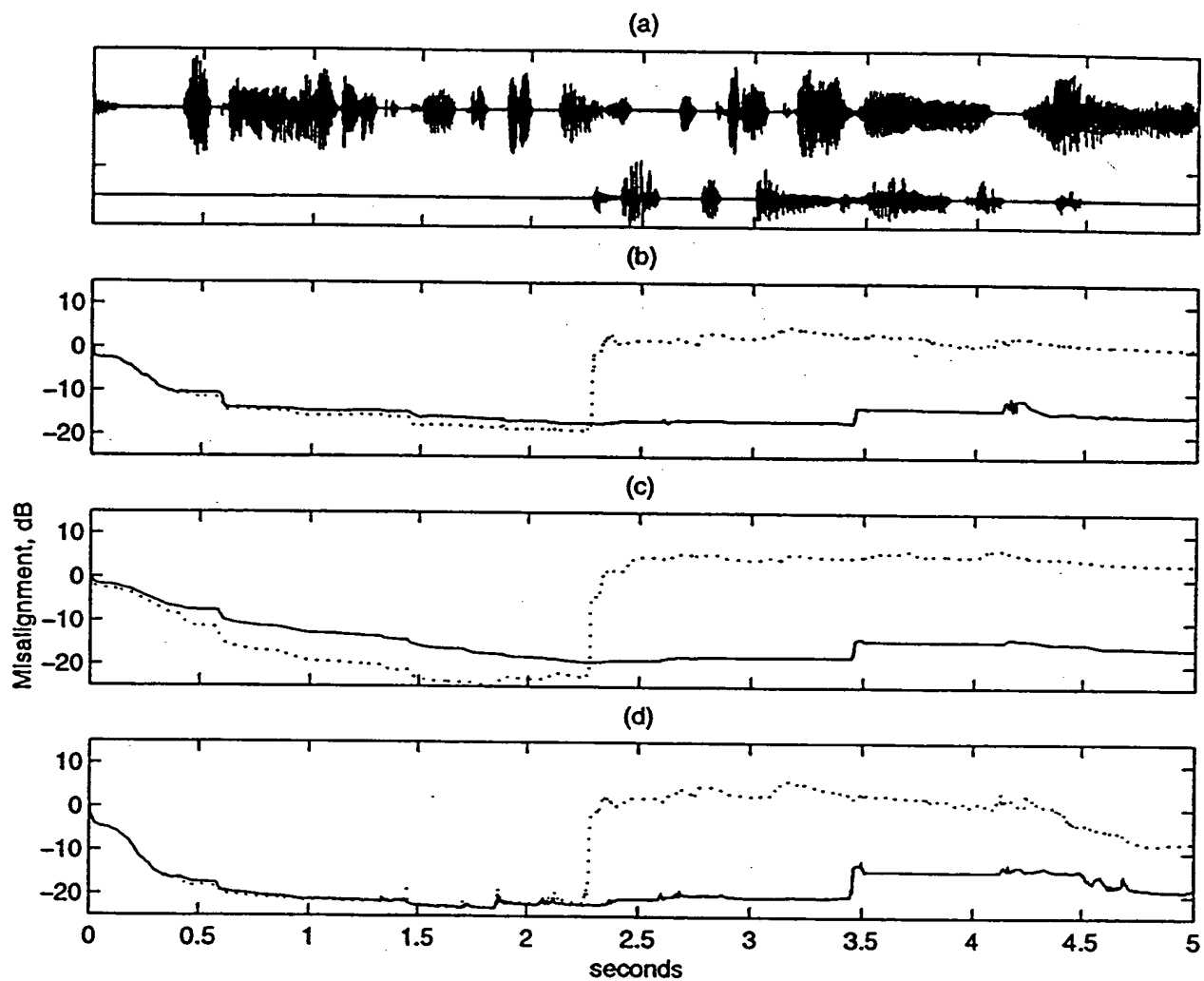


Figure 5: Misalignment during double-talk starting at 2.25 seconds. Far- to near-end ratio: 6 dB. (a) Far (upper) and near-end (lower) signals. (b) Solid line: R-PNLMS++, Dotted line: PNLMS++. (c) Solid line: R-APA, Dotted line: APA. (d) Solid line: R-PAPA, Dotted line: PAPA.

FIG. 16



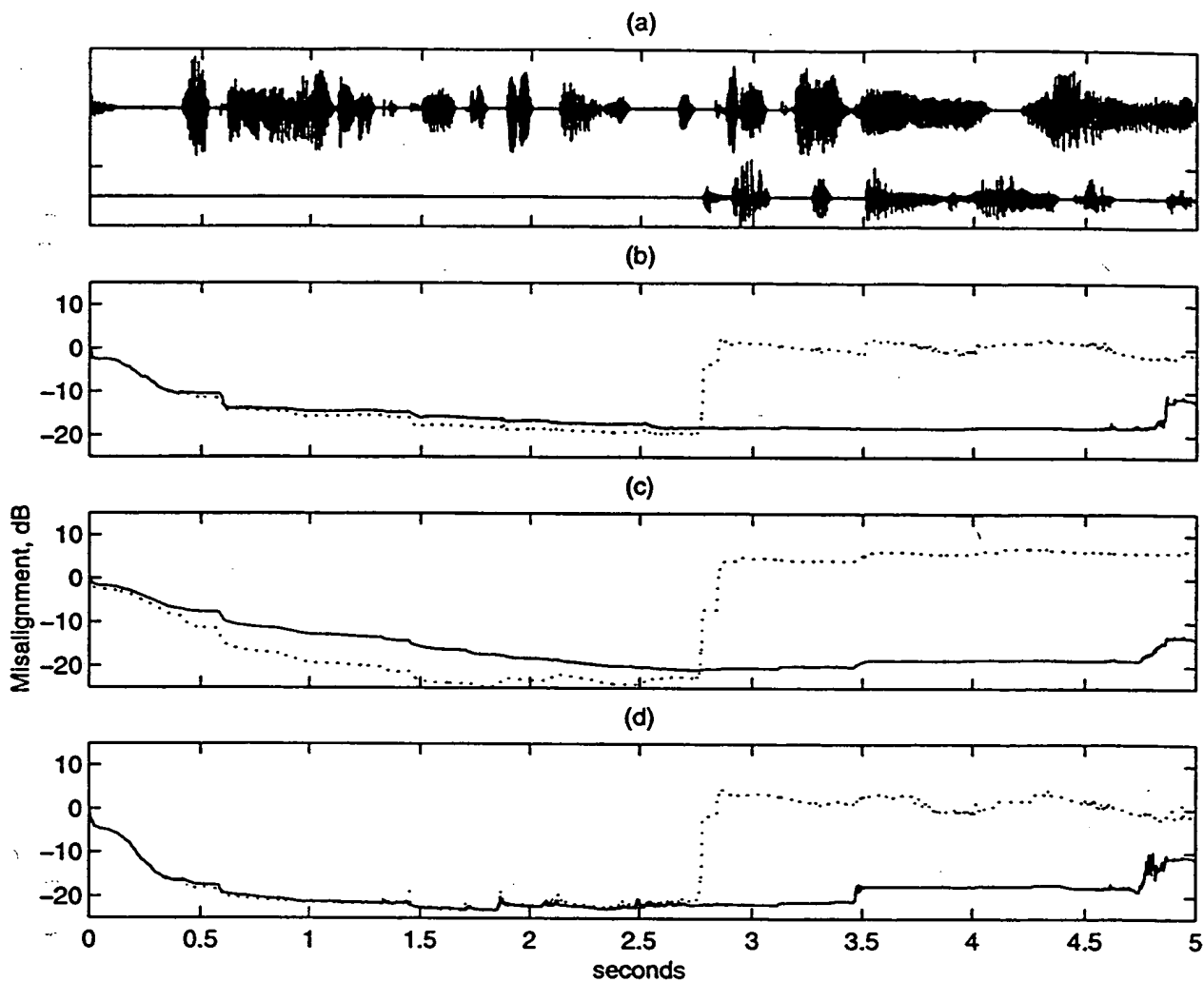


Figure 6: Misalignment during double-talk starting at 2.75 seconds. Far- to near-end ratio: 6 dB. (a) Far (upper) and near-end (lower) signals. (b) Solid line: R-PNLMS++, Dotted line: PNLMS++. (c) Solid line: R-APA, Dotted line: APA. (d) Solid line: R-PAPA, Dotted line: PAPA.

FIG. 17

FIG. 18

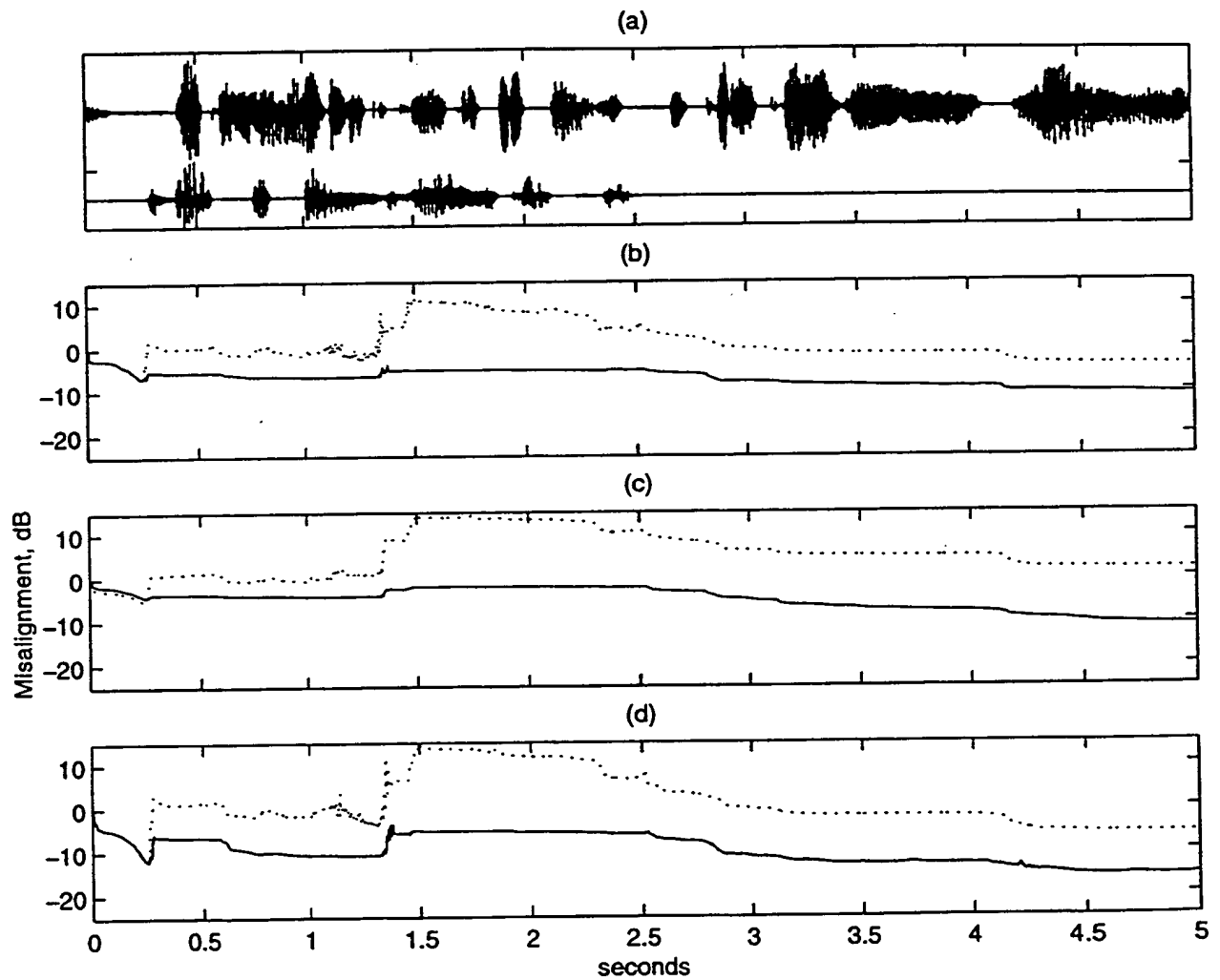


Figure 7: Misalignment during double-talk starting at 0.25 seconds. Far- to near-end ratio: 6 dB. (a) Far (upper) and near-end (lower) signals. (b) Solid line: R-PNLMS++, Dotted line: PNLMS++. (c) Solid line: R-APA, Dotted line: APA. (d) Solid line: R-PAPA, Dotted line: PAPA.

FIG. 19

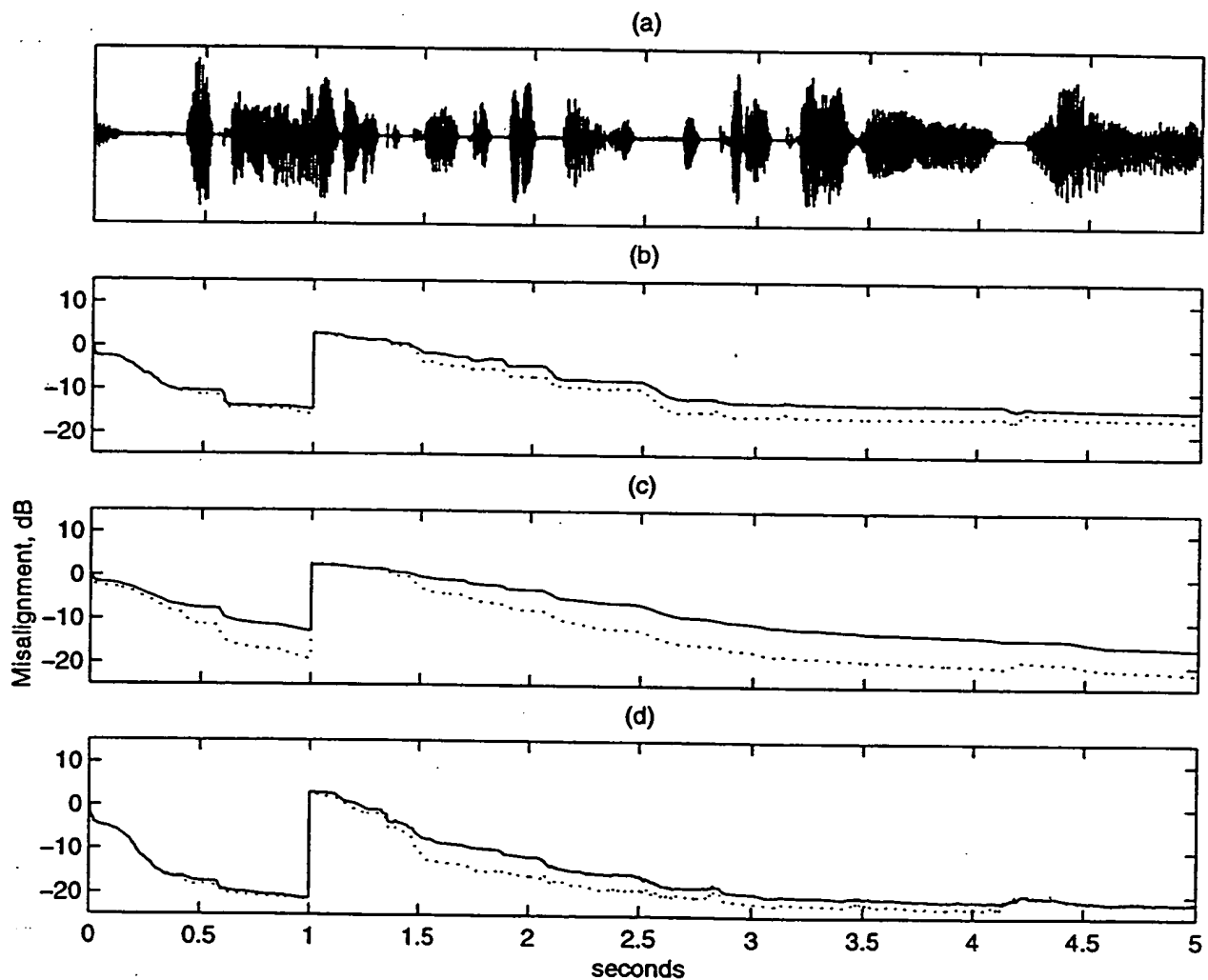


Figure 8: Misalignment after abrupt hybrid change occurring at 1 second. (a) Far (upper) and near-end (lower) signals. (b) Solid line: R-PNLMS++, Dotted line: PNLMS++. (c) Solid line: R-APA, Dotted line: APA. (d) Solid line: R-PAPA, Dotted line: PAPA.

FIG. 20

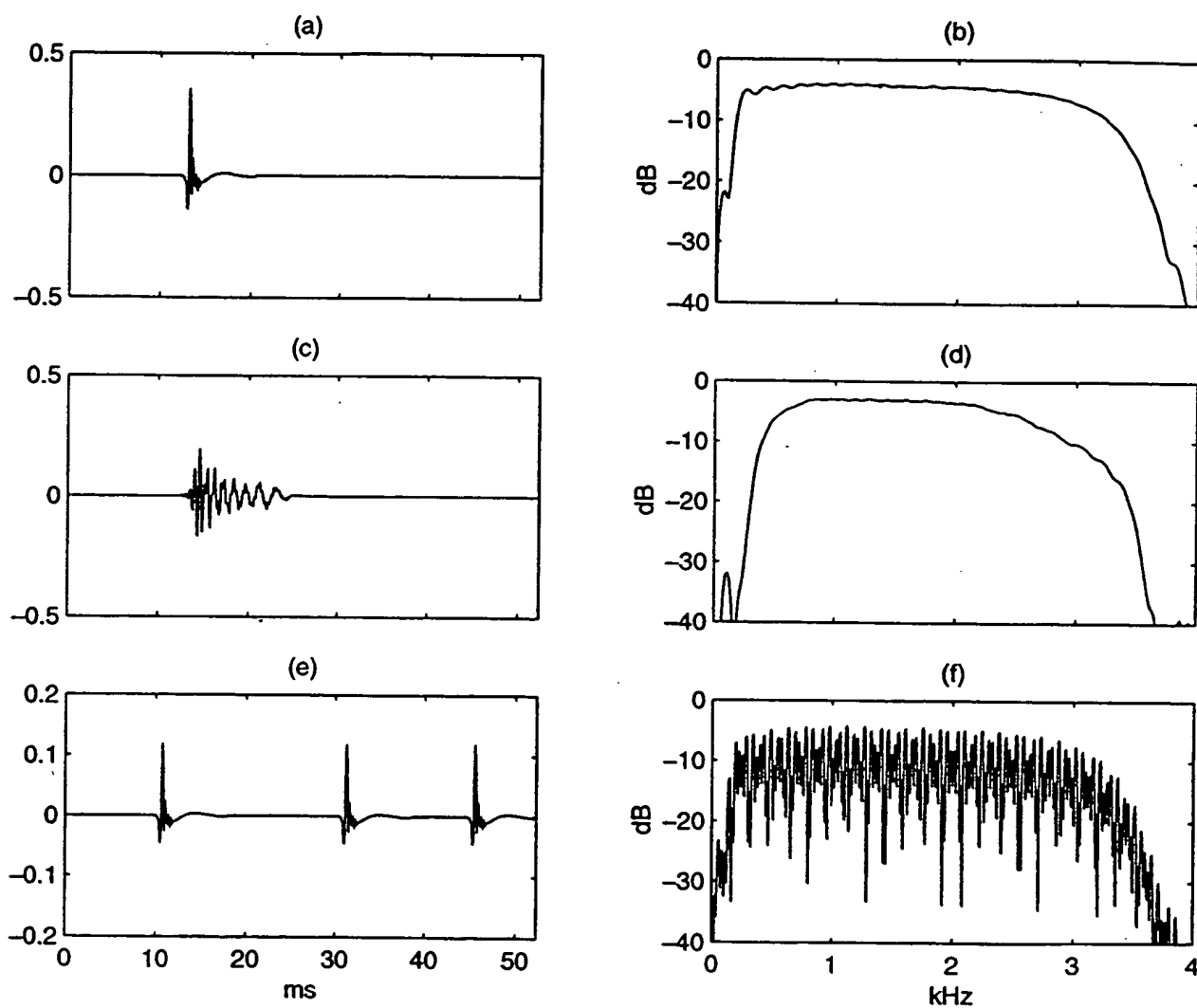


Figure 9: The three hybrids is Test 3a and Test 3b. (a, c, e) Impulse responses. (b, d, f) Corresponding magnitudes of the frequency responses.

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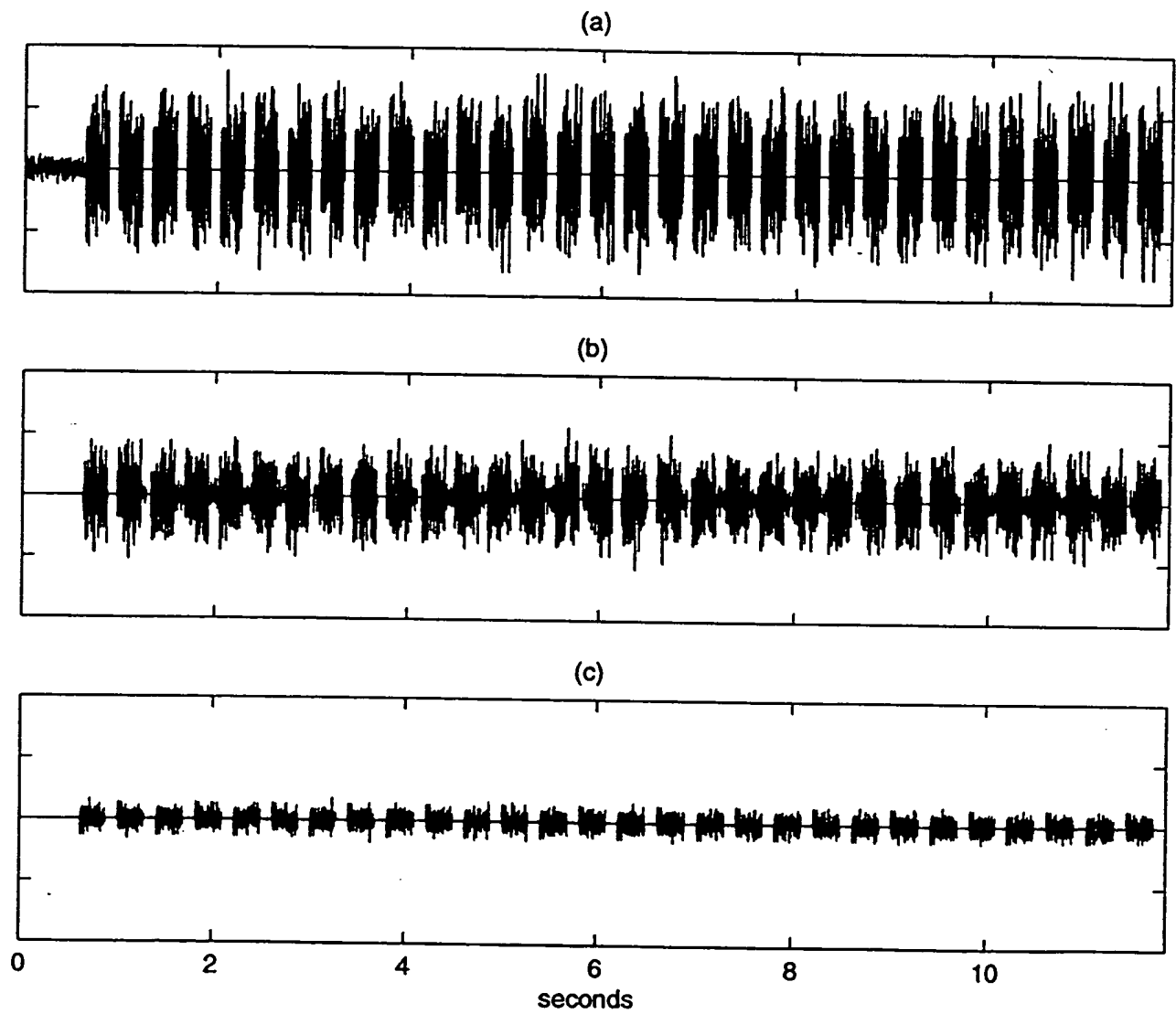


Figure 10: Signal for Test 3a. (a) Far-end signal. (b) Echo and near-end signal. (c) Near-end signal.

FIG. 21

FIG. 22

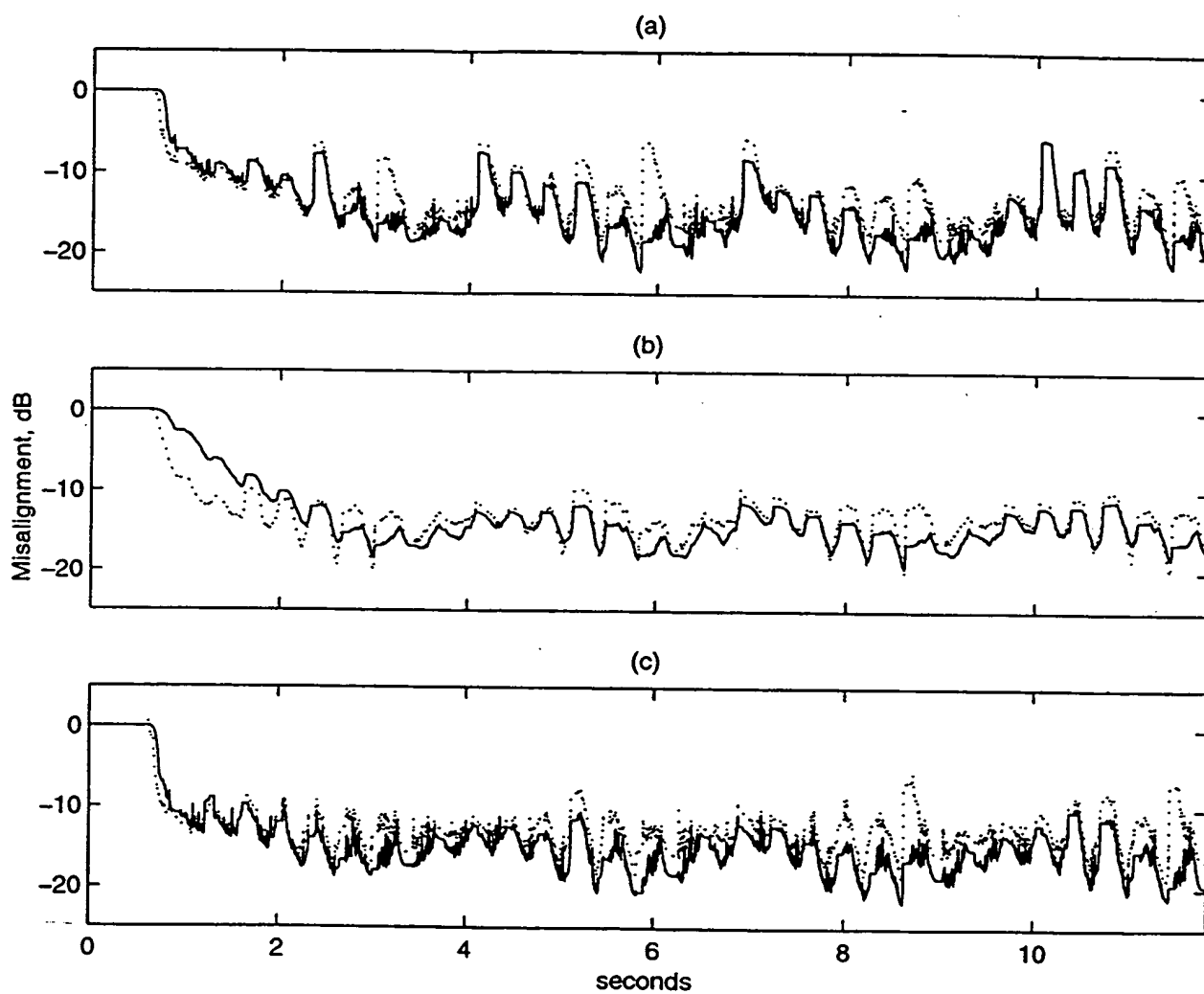


Figure 11: Misalignment Test 3a, hybrid in Fig. 9a (sparse) with 8 dB attenuation. (a) Solid line: Robust PNLMS++, dashed line: PNLMS++. (b) Solid line: Robust APA, dashed line: APA. (c) Solid line: Robust PAPA, dashed line: PAPA.

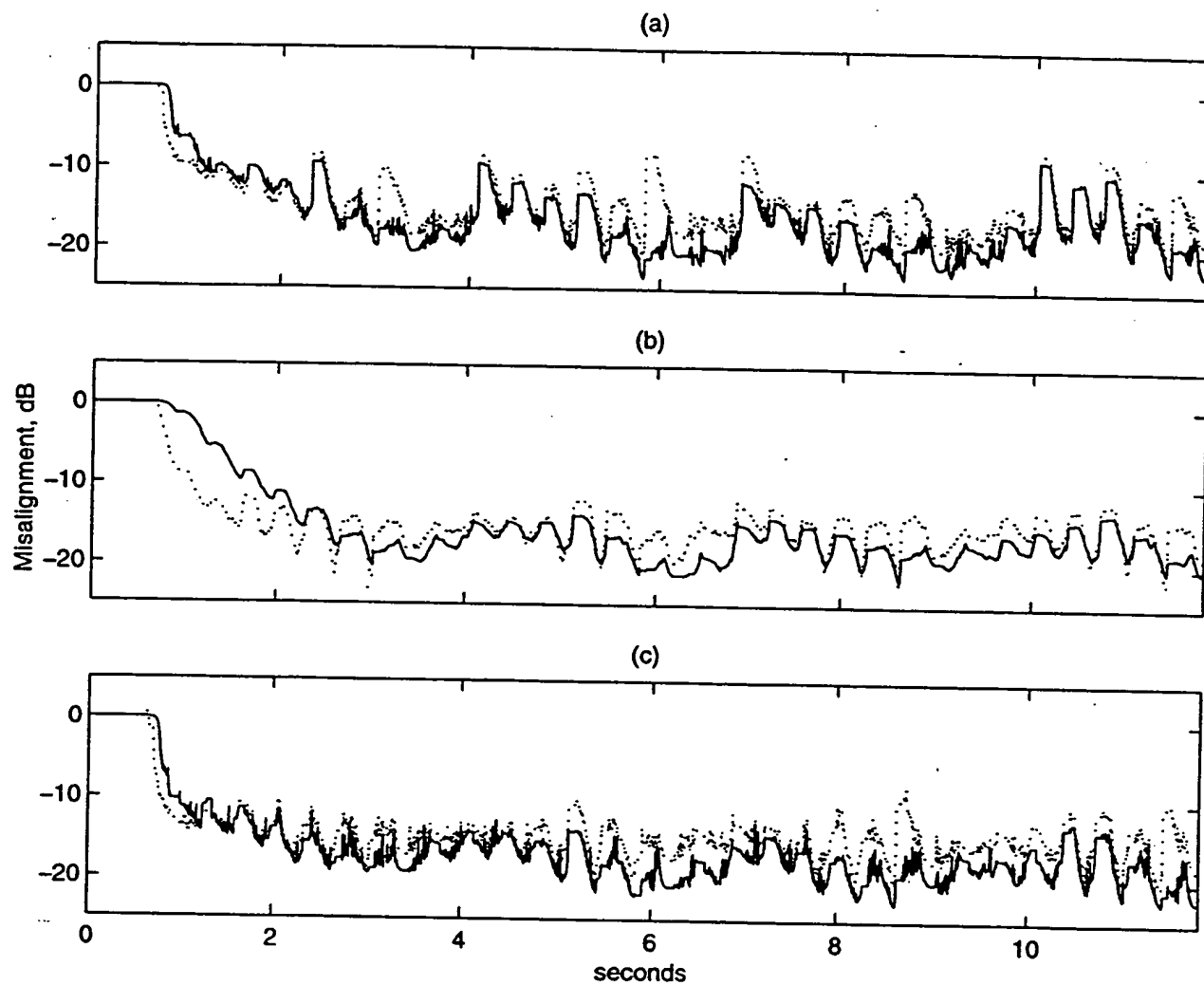


Figure 12: Misalignment Test 3a, hybrid in Fig. 9a (sparse) with 6 dB attenuation. (a) Solid line: Robust PNLMS++, dashed line: PNLMS++. (b) Solid line: Robust APA, dashed line: APA. (c) Solid line: Robust PAPA, dashed line: PAPA.

FIG. 23

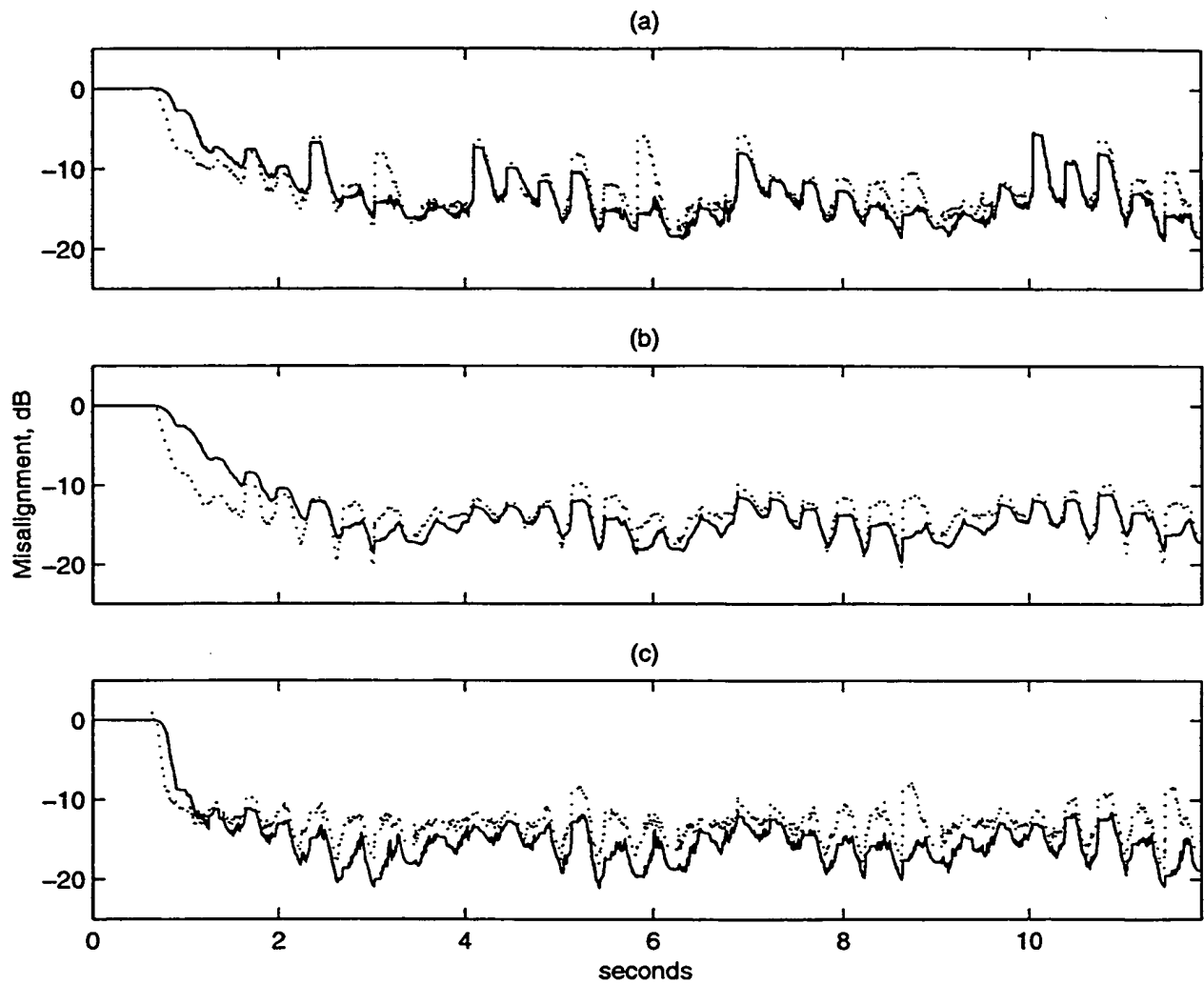


Figure 13: Misalignment Test 3a, hybrid in Fig. 9c (dispersive) with 8 dB attenuation. (a) Solid line: Robust PNLMS++, dashed line: PNLMS++. (b) Solid line: Robust APA, dashed line: APA. (c) Solid line: Robust PAPA, dashed line: PAPA.



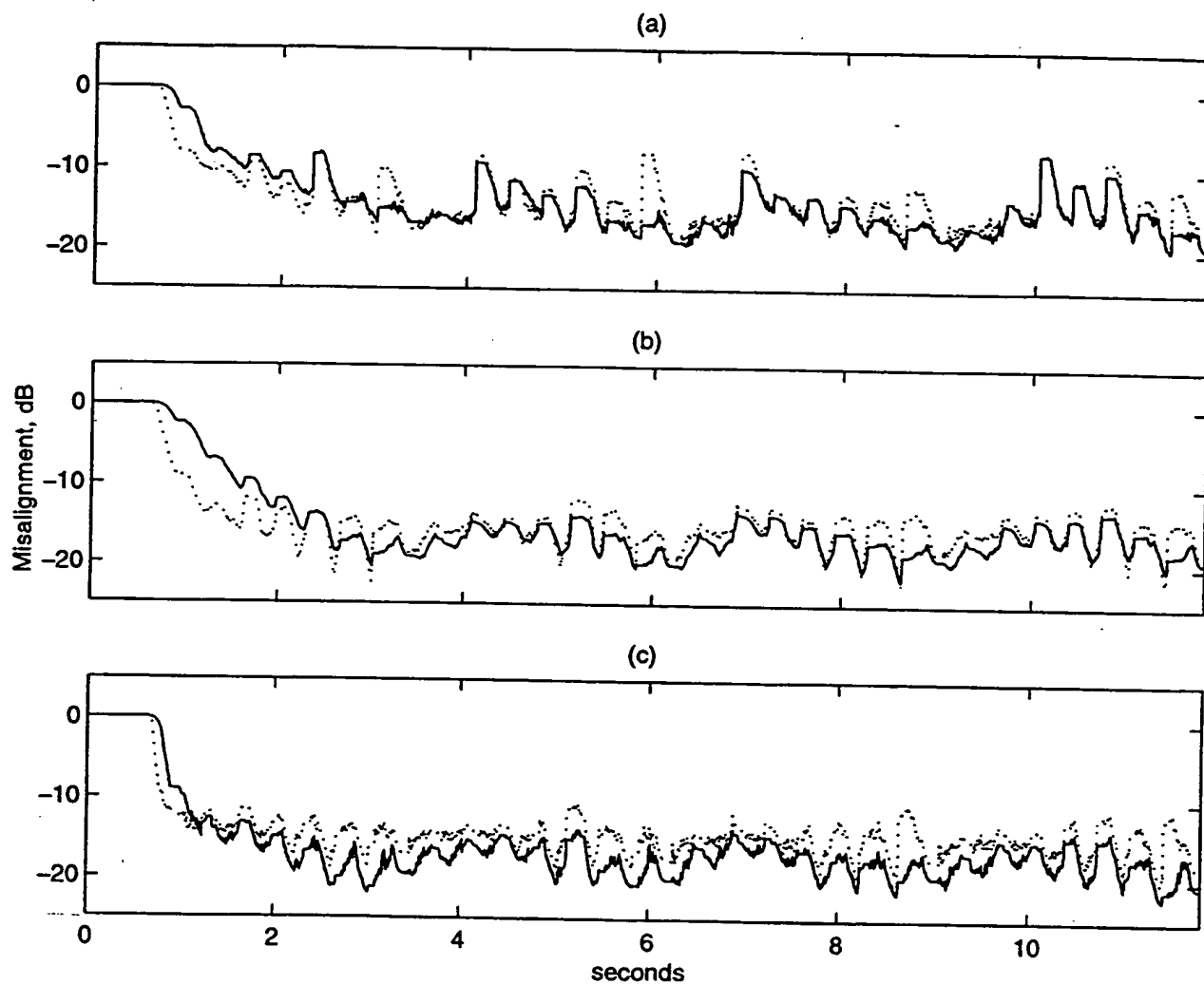


Figure 14: Misalignment Test 3a, hybrid in Fig. 9c (dispersive) with 6 dB attenuation. (a) Solid line: Robust PNLMS++, dashed line: PNLMS++. (b) Solid line: Robust APA, dashed line: APA. (c) Solid line: Robust PAPA, dashed line: PAPA.

FIG. 25

FIG. 26

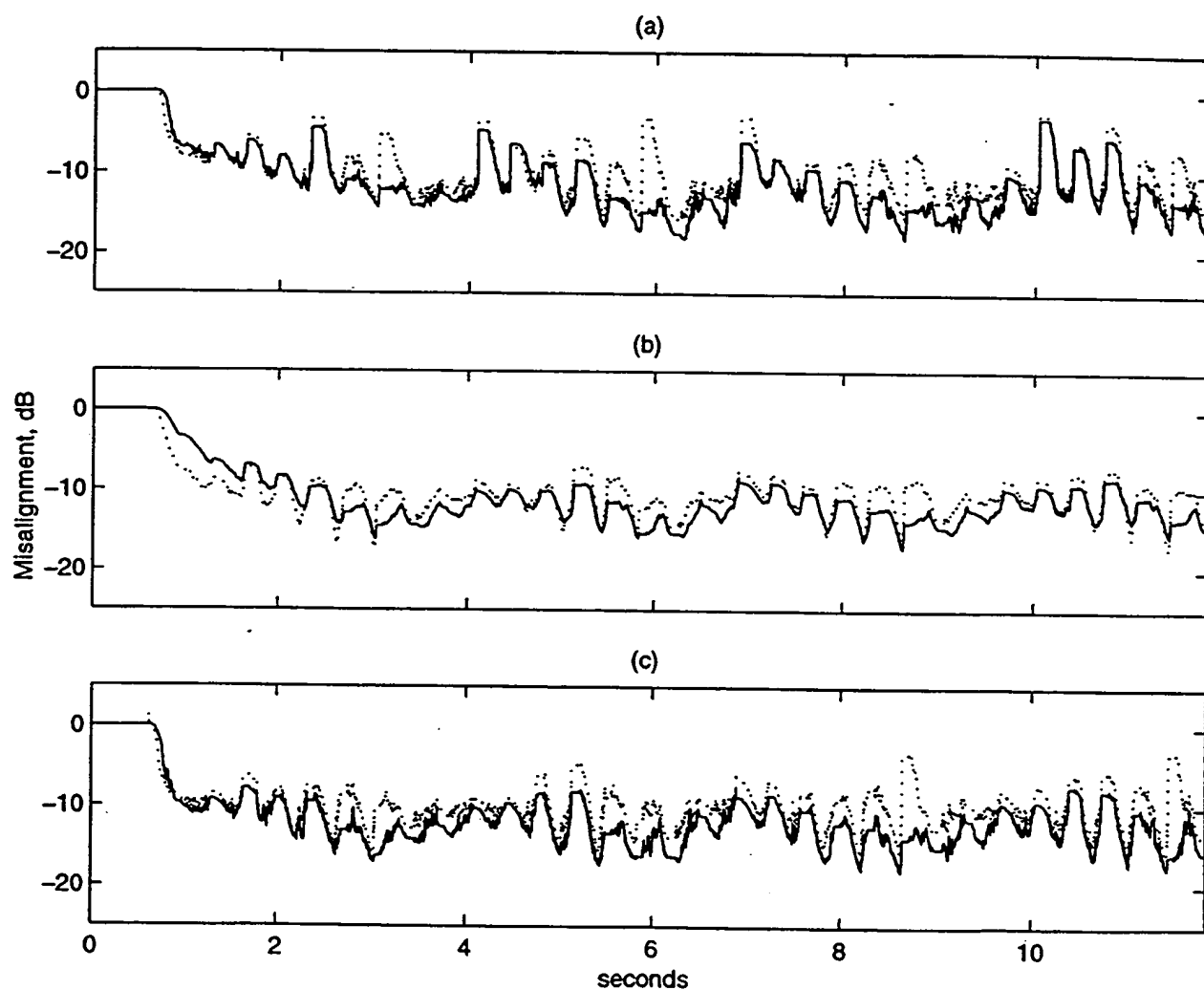


Figure 15: Misalignment Test 3a, hybrid in Fig. 9e (three short reflections) with 11 dB attenuation. (a) Solid line: Robust PNLMS++, dashed line: PNLMS++. (b) Solid line: Robust APA, dashed line: APA. (c) Solid line: Robust PAPA, dashed line: PAPA.



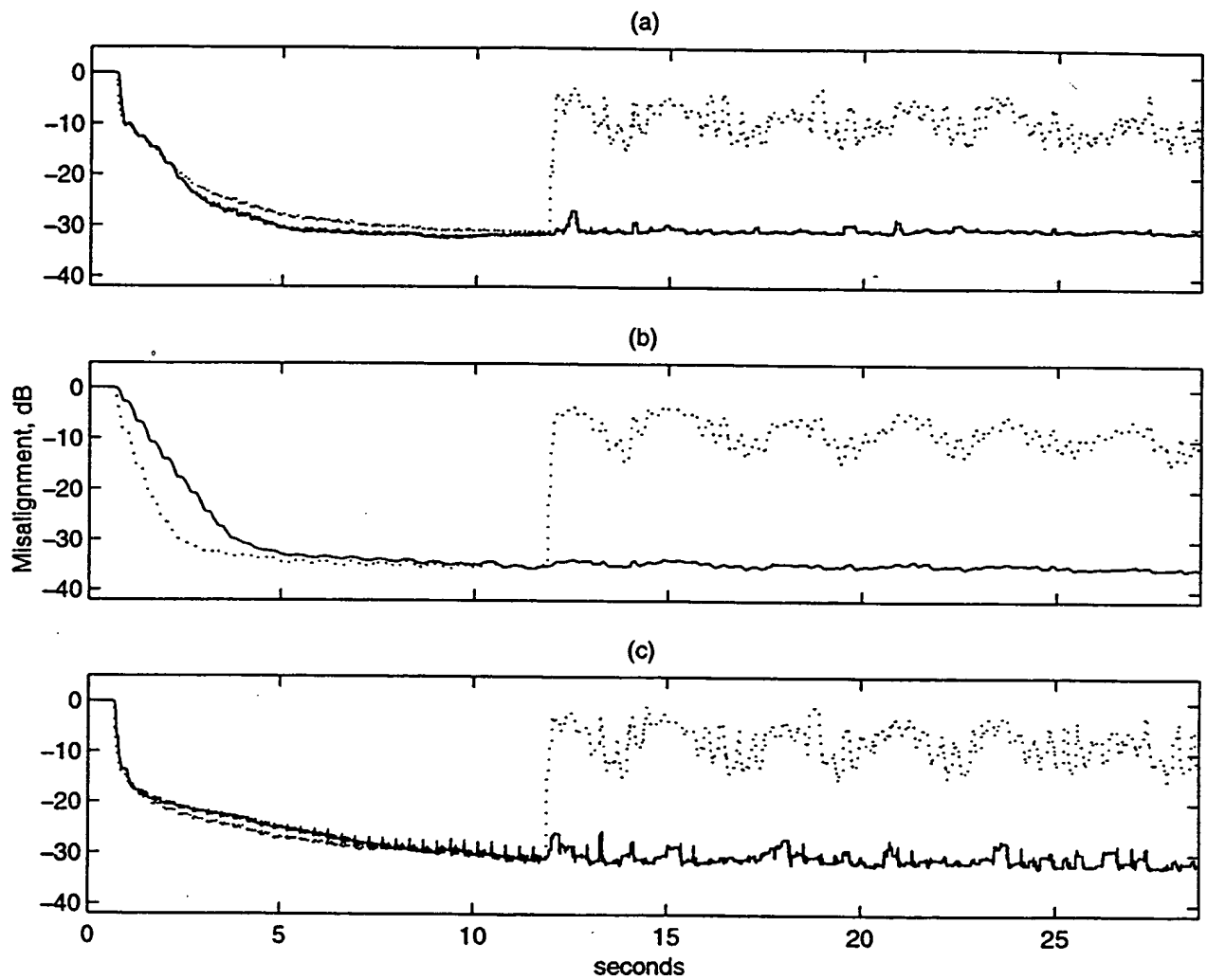


Figure 17: Misalignment Test 3b, hybrid in Fig. 9a (sparse) with 8 dB attenuation. (a) Solid line: Robust PNLMS++, dashed line: PNLMS++. (b) Solid line: Robust APA, dashed line: APA. (c) Solid line: Robust PAPA, dashed line: PAPA.

FIG. 28

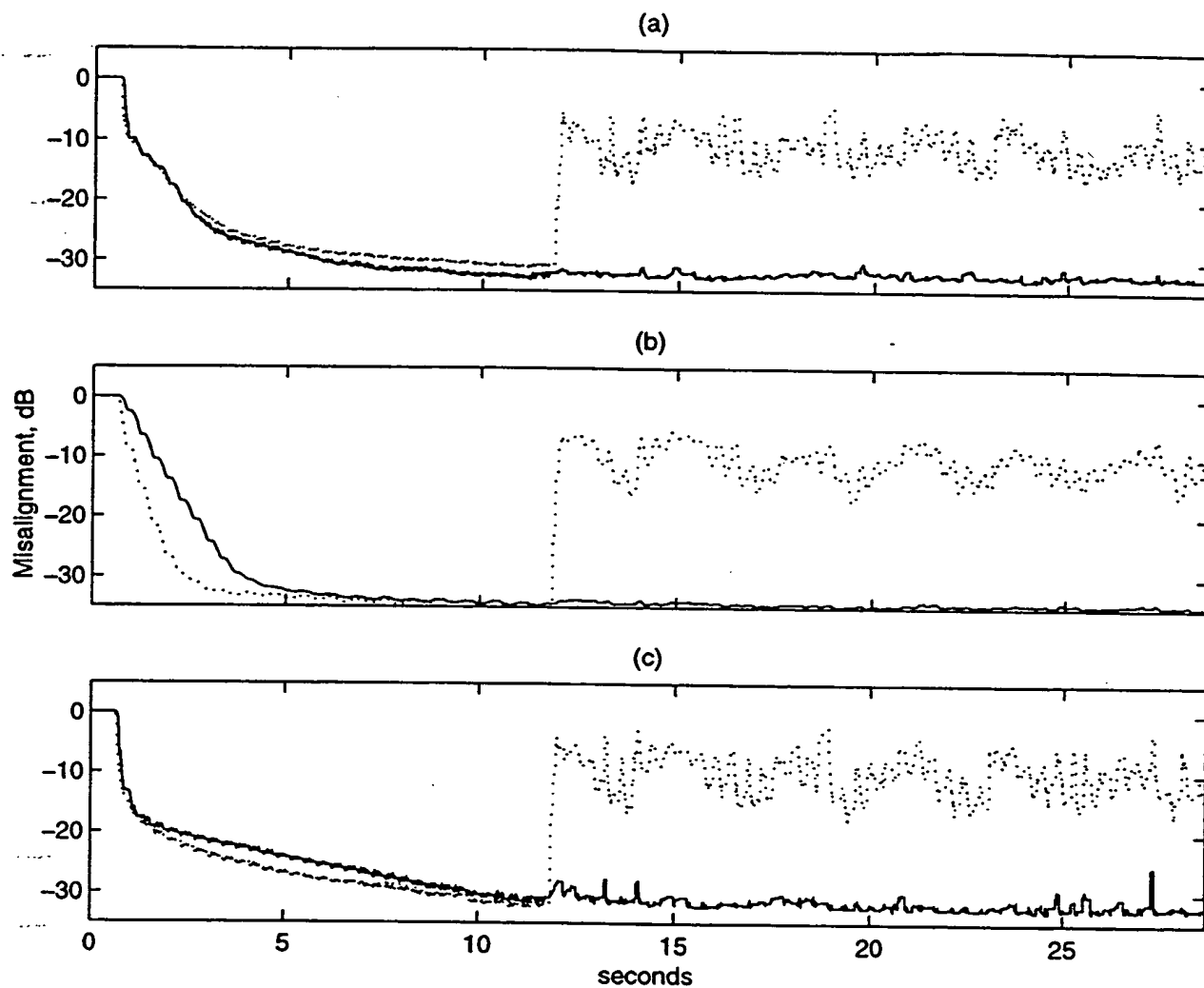


Figure 18: Misalignment Test 3b, hybrid in Fig. 9a (sparse) with 6 dB attenuation. (a) Solid line: Robust PNLMS++, dashed line: PNLMS++. (b) Solid line: Robust APA, dashed line: APA. (c) Solid line: Robust PAPA, dashed line: PAPA.

FIG. 29

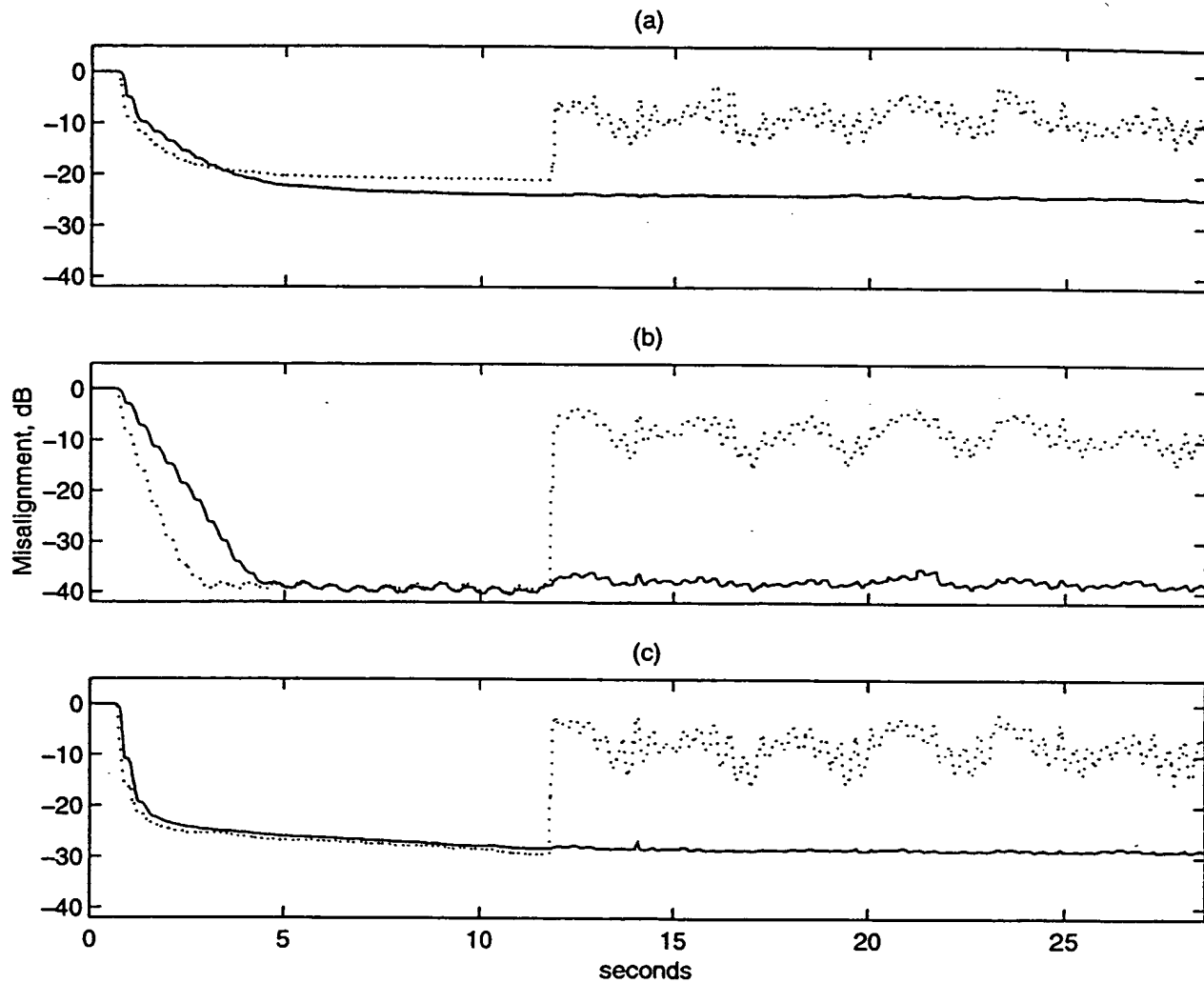


Figure 19: Misalignment Test 3b, hybrid in Fig. 9c (dispersive) with 8 dB attenuation. (a) Solid line: Robust PNLMS++, dashed line: PNLMS++. (b) Solid line: Robust APA, dashed line: APA. (c) Solid line: Robust PAPA, dashed line: PAPA.

FIG. 30

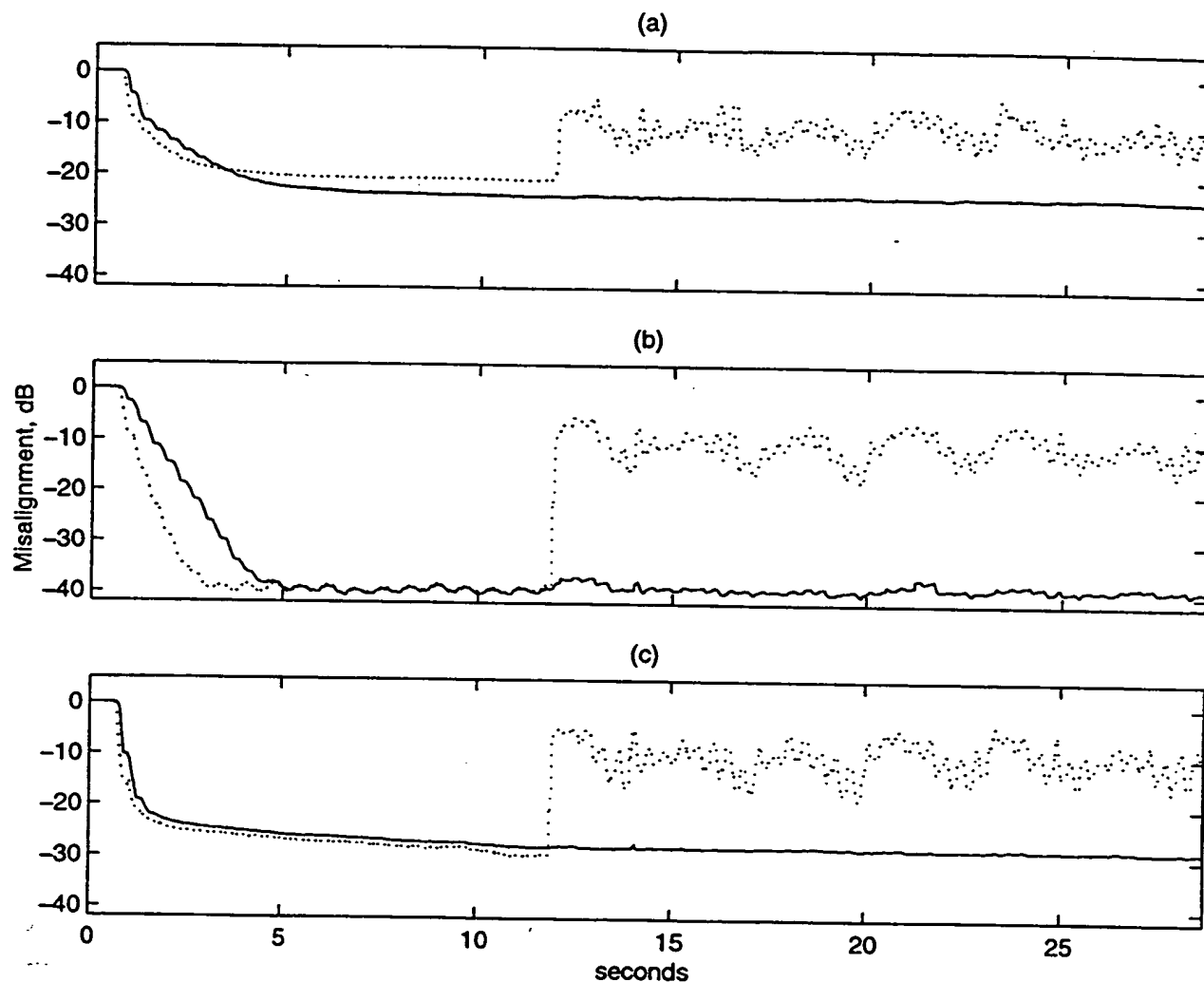


Figure 20: Misalignment Test 3b, hybrid in Fig. 9c (dispersive) with 6 dB attenuation. (a) Solid line: Robust PNLMS++, dashed line: PNLMS++. (b) Solid line: Robust APA, dashed line: APA. (c) Solid line: Robust PAPA, dashed line: PAPA.

FIG. 31

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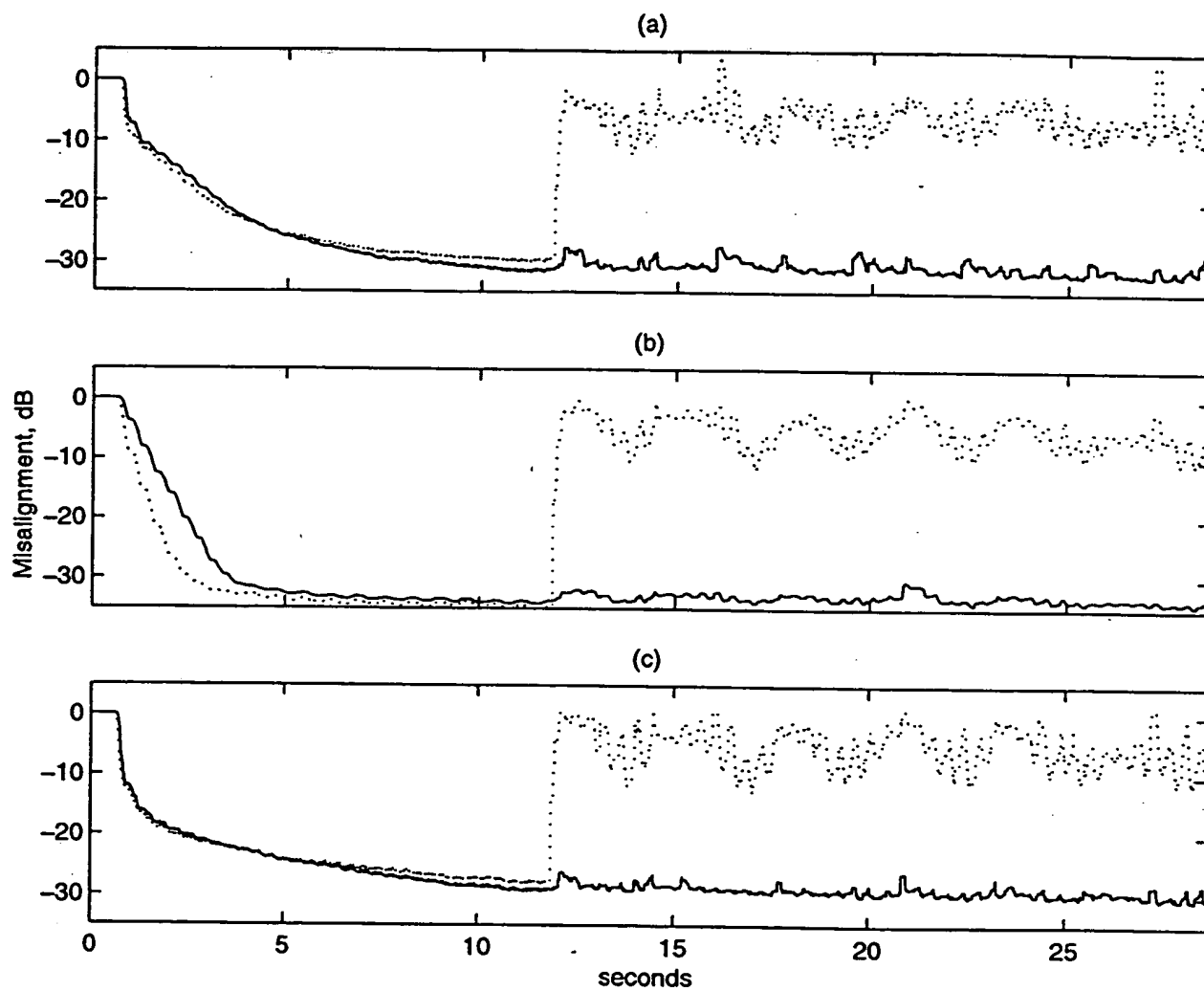


Figure 21: Misalignment Test 3b, hybrid in Fig. 9e (three short reflections) with 11 dB attenuation. (a) Solid line: Robust PNLMS++, dashed line: PNLMS++. (b) Solid line: Robust APA, dashed line: APA. (c) Solid line: Robust PAPA, dashed line: PAPA.

FIG. 32